CHARACTERISING BATCH TO BATCH VARIABILITY IN GYPSUM PRODUCTS

Gypsum powders are used worldwide in a variety of industries, for example in in the construction industry as a finishing material or in passive fire protection, and in medical applications as a support material in orthopaedic casts. The calcined powder reacts readily with water to form a slurry that can then be worked into the desired shape before exothermically curing to form a solid mass.

Gypsum is a natural product, and can be mined from multiple sources. A manufacturing method that processes these multiple sources to produce a consistent product is essential, as even subtle variation between batches will lead to differences in the behaviour of the material across the diverse range of applications and processes. A method of accurately quantifying differences in the properties of gypsum batches that are known to impact process performance is therefore critical to ensuring batch consistency and product quality.

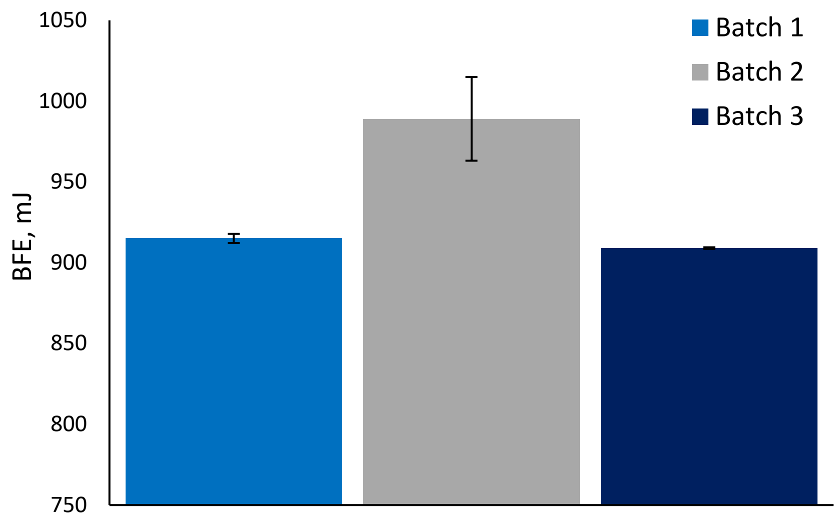
THE INFLUENCE OF DIFFERENT GYPSUM SOURCES

Three batches of gypsum plaster were produced using an identical manufacturing process, but using raw material from three different sources. Varying performance was observed between the batches in terms of their hydration behaviour. The three batches were identical in terms of particle size and distribution due to consistency in the production process.

Samples from the three batches were analysed using an FT4 Powder Rheometer®.

TEST RESULTS

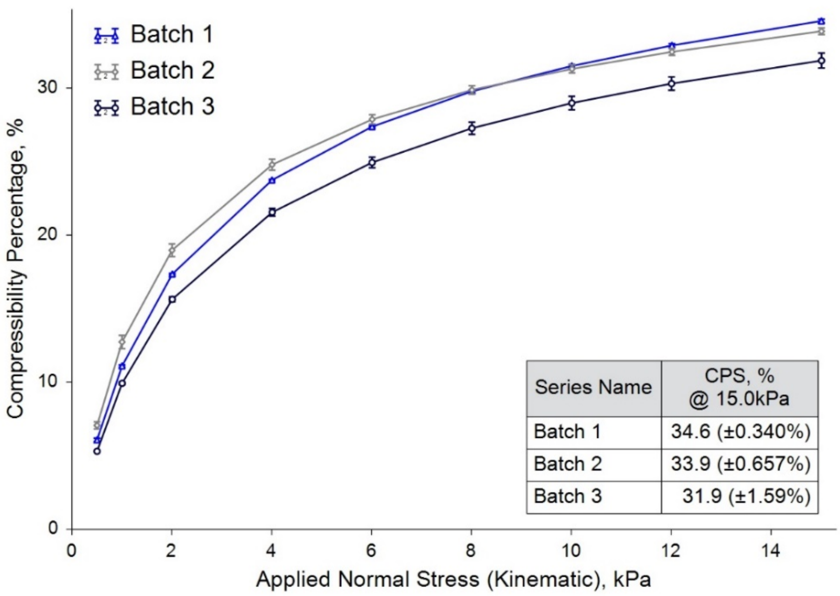
Dynamic Testing: Basic Flowability Energy



Batch 2 generated the highest BFE of the three samples, indicating a greater resistance to confined flow. This is likely to represent the conditions present during the hydration stage when the powder is mixed with water.

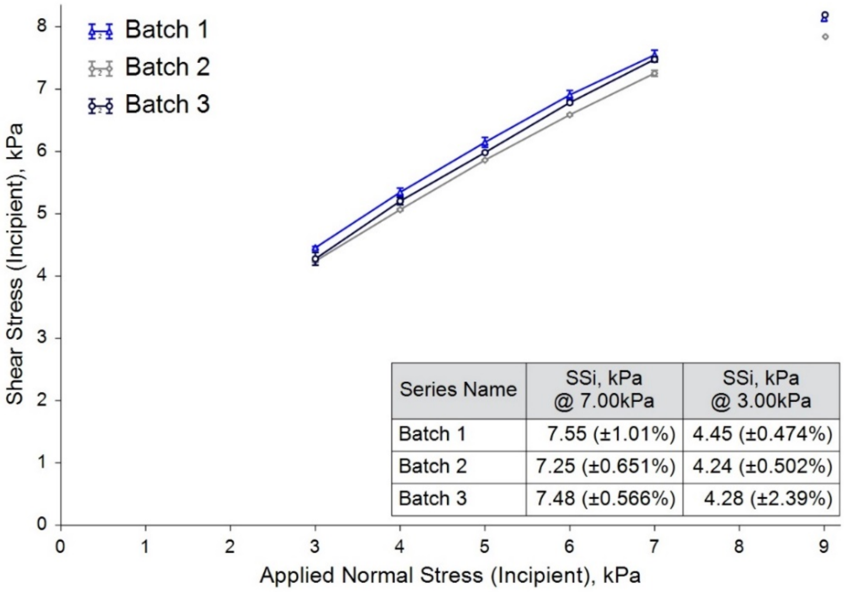
The higher deviation seen in the test results for Batch 2 also suggests greater variation through the bulk of the material, potentially leading to inconsistent performance in the final application.

Bulk Testing: Compressibility



Batch 3 exhibited a lower Compressibility than the other two samples. Low Compressibility indicates that a powder is more uniformly packed and entrains less air within the bulk. This is a property typically associated with more free-flowing powders.

Shear Cell Testing



Series Name	SSi, kPa @ 7.00kPa	SSi, kPa @ 3.00kPa
Batch 1	7.55 (±1.01%)	4.45 (±0.474%)
Batch 2	7.25 (±0.651%)	4.24 (±0.502%)
Batch 3	7.48 (±0.566%)	4.28 (±2.39%)

Limited differentiation was observed between the three samples in this test. Furthermore, the yield loci for the samples are not linear, meaning that Mohr's circle analysis of the data, which relies on the application of a Best Fit Line to the data, will not generate parameters that accurately describe the behaviour of the powder.

Shear cells are designed to model the incipient flow of powders under high levels of consolidation. These are not conditions typically present in common applications of gypsum powders, so it is not unexpected that the test results do not provide a clear differentiation between the samples.

CONCLUSIONS

The FT4 has identified clear and repeatable differences between three similar materials which exhibited varying performance in process. By considering the BFE and Compressibility values, it is possible to separate all three samples, where a single technique alone was unable to differentiate entirely. Batch 2 demonstrates the greatest resistance to forced flow (higher BFE), but a similar Compressibility to Batch 1, whereas Batch 3 has the lowest Compressibility, but has a similar BFE to Batch 1. This indicates that the various properties of powders are not necessarily related to each other, and that no single property entirely defines flowability. Each property must be measured directly and analysed in context, rather than trying to infer one property from another. Furthermore, the results demonstrate that Shear Cell testing alone may not provide a reliable representation of powder behaviour in this process, due to the differing stress and flow regimes present.

Powder flowability is not an inherent material property, but is more about the ability of powder to flow in a desired manner in a specific piece of equipment. Successful processing demands that the powder and the process are well-matched and it is not uncommon for the same powder to perform well in one process but poorly in another. This means that several characterisation methodologies are required, the results from which can be correlated with process ranking to produce a design space of parameters that correspond to acceptable process behaviour. Rather than relying on single number characterisation to describe behaviour across all processes, the FT4's multivariate approach simulates a range of unit operations, allowing for the direct investigation of a powder's response to various process and environmental conditions.

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